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CERTIFICATION

I, the below named translator, hereby declare that: my name and post office address are as stated below; that I am knowledgeable in the English and German languages, and that I believe that the attached text is a true and complete translation of PCT/EP2004/052187, filed with the European Patent Office on September 15, 2004.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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1 Description

2 OPTICAL MODULE COMPRISING A SPACER ELEMENT BETWEEN THE HOUSING
3 OF A SEMICONDUCTOR ELEMENT AND A LENS UNIT

4 The invention relates to an optical module with a circuit
5 carrier, a housed semiconductor element arranged on the circuit
6 carrier and a lens unit for projecting electromagnetic
7 radiation along an optical axis onto the semiconductor element,
8 with the housed semiconductor element and the lens being
9 embodied as two components.

10 The invention further relates to an optical system with an
11 optical module embodied in this way.

12 Generic optical modules and systems are used especially in
13 automotive technology.

14 In such cases operation can be with electromagnetic radiation
15 from different frequency ranges, in which case cumulatively to
16 the visible light, with which applications in the exterior area
17 of a motor vehicle typically operate, such as LDW (Lane
18 Departure Warning), BSD (Blind Spot Detection), or (Rear View
19 Cameras), the infrared light which is invisible to the human
20 eye is preferred for applications in the interior of the motor
21 vehicle such as OOP (Out of Position Detection) or for
22 additional outside illumination of a night vision system.

23 High demands are imposed on applications in the interior and
24 exterior area of a vehicle as a result of external influences
25 such as temperature, moisture, contamination and vibration. The
26 typical lifetime for systems in the motor vehicle is around 10
27 to 15 years, with only extremely low failure rates being
28 tolerated, so that the components of an optical system of the
29 type mentioned at the start may only exhibit very slow ageing.

1 Since in many cases the space for installing optical modules or
2 optical systems is very restricted, additional difficulties
3 arise in implementing the optical systems. It is thus extremely
4 difficult using conventional means to construct a hermetically
5 sealed reliable unit consisting of a camera chip (currently CCD
6 or CMOS sensors) and optics.

7 To achieve sufficiently sharp focus for a camera system,
8 consisting of an image sensor (currently CCD or CMOS) and a
9 lens system, the sensor and optics components must be matched
10 geometrically very precisely to one another. The tolerance
11 range for the distance from camera chip to optics in the z-axis
12 usually lies within the range of a few hundredths of a
13 millimeter, in order to achieve an optimally sharp image for a
14 specific depth of field. This is a particularly a problem for
15 so-called fixed-focus systems, since this tolerance which is
16 small in any event may be exceeded during manufacturing. An
17 additional consequence of an offset of camera chip to optics in
18 the x- or y-axis is also that under some circumstances the
19 optical system "squints", i.e. the image is truncated on one
20 edge (horizontal or vertical), since the offset means that
21 pixels are no longer present here and would have to be provided
22 as a precaution.

23 A further problem is presented by "tilt", i.e. a misalignment
24 of the camera chip around the x- or y-axis, resulting in the
25 image exhibiting an out-of-focus gradient in the horizontal or
26 vertical direction. In addition a "rotation" can also be
27 produced, i.e. a rotation around the z-axis of camera chip to
28 optics.

29 Almost all camera systems currently on the market which are
30 supplied with a fixed focus setting need an additional
31 compensation step during manufacturing, in which the distance
32 from camera chip to optics along the z-axis is set and is fixed

1 at this value. This is done for example using a thread and a
2 corresponding adjustment screw or a glue connection. A
3 compensation step can also be necessary for the x-y offset or,
4 if this is not done, a correspondingly larger sensor can be
5 provided which provides more pixels to allow for the
6 tolerances. Software which processes or calibrates out the
7 rotation is also known. Since otherwise sharp image information
8 is present, the pixels only need to be reassigned in a type of
9 "calibration" process. However there can no longer be any
10 information at the edges or corners since these are truncated.
11 Finally, a purely mechanical reduction of "tilt" and "rotation"
12 between chip and optics can as a rule only be achieved with
13 usual systems by high-precision manufacturing and assembly or
14 by calibrating the components.

15 However cameras for specific low-cost applications such as
16 automotive, industry, digital camera, mobiles, toys etc. should
17 be manufactured from the standpoint of cost and of quality
18 assurance aspects where possible without adjustment procedures
19 between optics and camera chip, that is without making
20 adjustments to the focus on the optical surface of the CMOS or
21 CCD sensor. This basically conflicts with the stated
22 requirements.

23 One possibility for developing a focus-free system is to reduce
24 the sums of the possible tolerances and elements, so that the
25 module or system functions as a result of the design without
26 adjustment in at least one specific distance and temperature
27 range. Where the invention is used for example within the
28 framework of an occupant protection system of a motor vehicle,
29 to which the present invention is however not restricted,
30 sharper images at distances of for example 15 cm to 130 cm as
31 well as at temperatures of for example - 40°C to + 105°C should
32 be able to be guaranteed. The fewer elements are included in

1 the tolerance chain, the easier this is to implement. A large
2 element in the tolerance chain is taken up by the circuit
3 carrier for the camera chip (currently CCD or CMOS for
4 example). With housed semiconductor elements the soldered or
5 glued connections or such like necessary between the chip and
6 the circuit carrier in particular constitute a large element in
7 the tolerance chain.

8 Using only one lens avoids additional optical tolerances being
9 caused by a complicated lens construction. The lens holder,
10 which is preferably made of plastic, can itself be connected to
11 the lens arrangement in different ways so that an exact optical
12 alignment of the lens arrangement and of the semiconductor
13 element in relation to the lens holder or the lens arrangement
14 respectively can always be ensured

15 However with systems which largely feature a classical layout
16 consisting of lens and camera chip, with the camera chip or the
17 semiconductor element being accommodated in a housing on a
18 suitable circuit carrier, it is difficult to get around the
19 given overall problems and simultaneously meet the given
20 quality requirements. With housed semiconductor chips it is
21 true to say that only particular measures need be taken to
22 protect the front of the package from outside light radiation
23 or other environmental influences, since the chip package
24 offers sufficient protection from behind, e.g. for the Silicon
25 which lets through IR radiation. The lens itself must however
26 be adjusted to the camera chip and feature a defined focusing.
27 This is done at present using tolerance-prone adjustment
28 options through screwing, gluing or such like, by means of
29 which the lens is fixed relative to the camera chip on the
30 circuit carrier.

31 The object of the invention is to make available an optical
32 module and an optical system with a housed semiconductor

1 element arranged on a circuit carrier in which any possible
2 tolerances which may remain can be compensated for, so that
3 with a simple and cost-effective assembly a reliable optical
4 quality without adjustment and especially focusing effort can
5 be provided and can be maintained over the lifetime of the
6 module or system.

7 This object is achieved with the features of the independent
8 claims. Advantageous embodiments of the invention, which can be
9 used individually or in combination with each other, are
10 specified in the dependent claims.

11 The invention builds on the generic optical module by
12 providing, outside the optical axis between the housing of the
13 semiconductor element and the lens unit at least one spacer
14 element, which is also referred to as a spacer. In this way any
15 remaining manufacturing tolerances between semiconductor
16 package and lens unit, as a result of wear to tools for example
17 or other differences within one or between different
18 manufacturing lots or producer-specific versions or such like
19 can be advantageously compensated for.

20 Preferably the spacer element is embodied as a foil or washer,
21 for example like a shim in the form of a circular washer.
22 Circular washers generally allow defined, e.g. planar surfaces
23 to be embodied, whereby an even support can be implemented
24 which advantageously largely eliminates the components tilting
25 in relation to one another.

26 To implement a simple production process the spacer element is
27 preferably a punched part. With spacer elements with a very
28 small thickness of a few tenths or hundredths of millimeters
29 especially, these parts can be advantageously punched from a
30 foil.

1 To make it easier to fix the spacer elements to the adjacent
2 components and/or to each other, the spacer element is embodied
3 with at least one adhesive side, preferably two. These types of
4 spacer elements can for example be manufactured simply from a
5 single-sided or double-sided adhesive tape or an adhesive foil,
6 preferably punched out.

7 In accordance with the invention the spacer element is
8 preferably part of a set of elements, preferably comprising two
9 or more spacer elements of different predefined thicknesses or
10 with one uniform basic thickness and increased or reduced
11 nominal dimensions in relation to this. A typical set of
12 elements would for example be spacer elements with nominal
13 differences in dimension from ± 0.005 mm or ± 0.01 mm to
14 ± 0.03 mm or such like. In this way any remaining tolerance
15 differences between semiconductor housing and lens unit can
16 basically be compensated for without any great adjustment
17 effort.

18 To improve the optical characteristics of a module at least one
19 spacer is embodied in accordance with the invention preferably
20 simultaneously as a diaphragm, lens hood or such like and can
21 thus reduce the need for special hoods.

22 The spacer element is made in an appropriate manner from a
23 plastic, for example of thermoplastic.

24 The invention further comprises an optical system with an
25 optical module of the type stated above. In this way the
26 advantages of the optical module can also be brought to bear
27 within the framework of an overall system.

28 The invention is based on the knowledge that any remaining
29 manufacturing tolerances, especially between housed
30 semiconductor chips and lens units of different lines of

1 products, can be compensated for simply and at low cost by
2 means of at least one specially embodied spacer element. The
3 optical module can thus be developed without moving parts such
4 as threads or fixing screws, which leads to greater
5 reliability. The smaller tolerances of the design, including in
6 the x- and y-axis, mean that the chip surface do not have to be
7 unnecessarily large, which makes the camera chip cheaper. Such
8 a module can be a very compact design which has the advantage
9 of allowing the camera module to also be used in applications
10 where space is restricted.

11 The invention can be employed especially usefully in the
12 implementation of video systems, if necessary in combination
13 with radar systems, ultrasound systems or such like in the
14 automotive area.

15 The invention is now explained with reference to the
16 accompanying drawings with reference to preferred embodiments.

17 The figures show schematic diagrams of:

18 Fig. 1 the arrangement of an inventive spacer element, shown
19 in a cross-sectional view of an inventive optical
20 module with a client-specific semiconductor element
21 housing.

22 Fig. 2 an enlarged section X of the module in accordance with
23 Fig. 1;

24 Fig. 3 a spacer element used in accordance with the invention,
25 shown on its own; and

26 Fig. 4 the arrangement of an inventive spacer element in a
27 cross-sectional view of an inventive optical module
28 with a client-specific semiconductor element housing.

29 In the description of the preferred embodiment of the present

invention below the same reference symbols refer to the same or comparable components.

Figures 1 to 5 show, in different cross-sections and views, the arrangement of an inventive spacer element 35 in an optical module with a circuit carrier 10; A housed semiconductor element 12 and a lens unit 14; 16, 18, 20; 21 for projecting electromagnetic radiation along an optical axis 33 onto the semiconductor element 12 arranged on the circuit carrier 10.

The lens unit 14; 16, 18, 20; 21 embodied separately from the housed semiconductor element 12 comprises a lens holder 14 and a lens arrangement 16, 18, 20; 21 with at least one lens 20 and if necessary one diaphragm 21.

The semiconductor element 12 can be arranged in a standard housing (cf. Fig. 4 below) or in a client-specific SMD housing (cf. Fig. 1 and 2).

The exemplary embodiment depicted in Fig. 1 is based on a client-specific SMD housing 13. A support 13a is for example embodied on at least sections of this housing 13, on which the lens unit 14; 16, 18, 20; 21 is supported. The lens unit 14; 16, 18, 20; 21 is supported either via the lens 16, which is preferably embodied as a type of support lens 16, or via the lens holder 14 (not shown). Support lens 16 or lens holder in this connection feature at least one flat section 16a embodied at least in sections to correspond to support 13a, which for example is embodied flat and rests on the support 13a embodied on the package 13 of the semiconductor element 12. In addition, at least in some sections, the lens 16 or the lens holder features a skirt 16b, which is essentially embodied to correspond to a support surface 13b embodied on the support 13a. The support 13a is thus preferably embodied in the form of a ring skirt 13a. The support surface 13b of the ring skirt 13a is embodied, preferably conically, viewed in the direction of

1 the optical axis 33 of the module, so that not only for
2 automated production a type of self-centering of adjacent
3 components forward from the lens 16 and support 13a is
4 advantageously made possible more easily.

5 Preferably a lens arrangement 14; 16, 18, 20; 21 with a number
6 of lenses 16, 18, 20 and if necessary at least one diaphragm 21
7 is provided in the form of a package. The optical quality can
8 be improved by a lens with a number of lenses, which is also
9 possible within the framework of the present invention,
10 especially since it is possible to work with fine tolerances
11 here. In this context it is also especially advantageous for
12 the lenses 16, 18, 20 and where necessary the diaphragm 21 to
13 be in direct contact with each other. In practice this excludes
14 fluctuations of the lens arrangement 16, 18, 20; 21 in the z-
15 direction, meaning in the direction in which the lenses follow
16 each other. The tolerances not only depend on the lens
17 arrangement 16, 18, 20; 21 itself. Likewise it is especially
18 useful for the relative positions of the lenses to each other
19 to be determined by the geometry of the lenses 16, 18, 20 and
20 if necessary diaphragms 21. The arrangement of the lenses can
21 also be determined in the x-y direction by the lenses
22 themselves, by the contact surfaces of the lenses or diaphragms
23 being designed accordingly.

24 The lenses 16, 18, 20 or diaphragms 21 supported in the lens
25 holder 14 are preferably also formed so that they assume a
26 defined position within the lens holder 14 in relation to each
27 other. Furthermore at least one of the lenses 20 is designed,
28 so that it operates in conjunction with the lens holder 14 and
29 thus also assumes a defined position in relation to the
30 semiconductor element 12. In this manner all lenses 16, 18, 20
31 are adjusted in relation to the semiconductor element 12.

32 This adjustment will also not be compromised by the lens holder

1 14 being connected for example via a screw connection 23 to the
2 circuit carrier 10. The housed semiconductor element 12 is
3 arranged on the circuit carrier 10 via lead frames 30 for
4 example. In addition a glued connection 22 or other known
5 connection techniques can be provided.

6 It is especially useful for precisely one of the lenses or
7 diaphragms to be in direct contact with the lens holder (not
8 shown). Since the lenses define their positions relative to one
9 another, it is sufficient to fix precisely one lens or
10 diaphragm to the lens holder. In this way the overall lens
11 arrangement is aligned in relation to the semiconductor
12 element, which in the final analysis allows the advantageous
13 optical quality to be ensured. In this context it is especially
14 advantageous for the precisely one lens to be connected in a
15 waterproof and dustproof manner to the lens holder.

16 Advantageously the frontmost lens will be selected for this
17 purpose as the lens to form the seal with the lens holder. This
18 can be done in the following way for example; by the precisely
19 one lens being connected to the lens holder by ultrasound,
20 laser welding and/or gluing, if necessary alternatively or
21 cumulatively using screws and /or mastic.

22 There can also be provision for the lens arrangement to be a
23 snap-in fit in the area holding the lens by using retaining
24 means 32 (cf. Fig. 4). Exact positioning can also be ensured in
25 this way. Furthermore it should be stressed that this provides
26 an easier facility for separating the lenses from the other
27 components, especially the expensive semiconductor element. The
28 sealing effect is especially provided in an advantageous manner
29 in conjunction with a snap-on the assembly by the lenses
30 featuring a hard and a soft component, with the soft component
31 being arranged around the circumference of the lens to make the
32 seal (not shown). The soft component also supports the general

1 requirement for not introducing any strains into the lenses 16,
2 18, 20; 21 during snap-on assembly; Strains would always have a
3 negative effect on the optical characteristics.

4 Preferably in the exemplary embodiment in accordance with Fig.
5 1 the lens arrangement 16, 18, 20; 21 is retained via a
6 retaining element 15 (molded ring) in the lens holder 14. The
7 retaining element 15 preferably features one hard 15a and, at
8 least in sections, one permanently flexible component 15b. A
9 permanently flexible component 15b preferably embodied to run
10 around the circumference can especially also be used at the
11 same time to seal the lens arrangement 16, 18, 20; 21 against
12 moisture and dirt - as well as its own compensation function
13 for any mechanical and/or thermally produced strains which
14 occur. The permanently flexible component 15b is preferably
15 embodied on the circumference on which the lens 20 rests. In
16 the area of the harder component 15a the retaining element 15
17 is arranged on the area 14 retaining the lens, for example
18 ultrasound or laser welded, glued, riveted, molded or connected
19 by means of another method which is easy to automate. Screw and
20 snap-on connections are also conceivable. Preferably the hard
21 component 15a of the retaining ring 15 contains a thermoplastic
22 material. Accordingly a permanently flexible component 15b has
23 proven itself which preferably contains thermoplastic
24 elastomers (TPE) or Silicon or such like. For the purposes of
25 providing a uniform and easy-to-handle component 15 both the
26 permanently flexible component 15b is molded onto the hard
27 component 15a for example in accordance with a two-component
28 injection method or vice-versa.

29 It can further be especially advantageous for undesired optical
30 effects, especially as a result of light entering from the
31 side, to be prevented by darkening and/or applying a matt
32 surface or by using total reflection (not shown). This involves

1 examples of suitable measures.

2 Finally provision is usefully made for the module to be able to
3 be connected via a flat cable or especially when a flexible
4 printed circuit board is used as the circuit carrier, by means
5 of this to a rigid circuit board (the latter are all also known
6 as rigid-flex systems) especially (for example by means of hot
7 bar soldering) As regards angle and position etc. this is an
8 especially flexible solution for connecting the circuit carrier
9 10 or the module to a controller or a circuit board (not
10 shown).

11 For the purposes of compensating for any manufacturing
12 tolerances of the semiconductor chip 12 and/or the lens unit
13 14;16, 18, 20; 21, in accordance with the invention, at least
14 one spacer element, which does not adversely affect the entry
15 of the main beam 33 and is also referred to as a spacer, is
16 arranged outside the optical axis 33 between the housing 13 of
17 the semiconductor element 12 and the lens unit 14;16, 18, 20;
18 21. In the exemplary embodiment in accordance with Fig. 1 or 2,
19 that is a client-specific housed semiconductor element 12, the
20 spacer element lies between support 13a and the lens 16 or the
21 lens holder 14.

22 Fig. 3 shows an inventive spacer element on its own; For
23 example the spacer element 35 is punched out of a foil. Also
24 conceivable are spacer elements 35 embodied in the form of
25 rings for example in the shape of a circular washer. In any
26 event self-adhesive spacers 35 have proven themselves in a
27 manufacturing and assembly. Preferably in accordance with the
28 invention the spacer element 35 is part of a set of elements a,
29 b, c, with at least two or more spacer elements 35a, 35b, 35c
30 of uniform predefined basic thickness and of different nominal
31 dimensions increasing or reducing these elements in each case.
32 For example the set of elements a, b, c, can comprise distance

elements 35 with nominal dimension changes from ± 0.005 mm or ± 0.01 mm to ± 0.03 mm or such like. In an advantageous development of the optical characteristics of the module the distance element 35 can preferably be embodied as a diaphragm, a lens hood or such like, which, depending on application design, advantageously allows a reduction in its parts.

Fig. 4 shows the arrangement of an inventive spacer element 35 in a cross-sectional view of an inventive optical module with a standard housed semiconductor element 12. In this case the spacer 35 element rests against a transparent glass cover 36 which protects the sensitive surface 34 of the semiconductor chip 12 in particular against dust etc. With standard chips without covers (not shown) the spacer element 35 can obviously also be arranged directly on the chip housing 13.

With the present invention any manufacturing tolerances, e.g. of the supports 13a of a client-specific chip housing 13 or valuable lens units 14; 16, 18, 20; 21 or such like can advantageously be adapted by easy-to-handle spacer elements 35, which are preferably available in the form of a set of elements a, b, c, ... for typical thicknesses for lines of products of different manufacturing quality. Whereas previously lines of products which did not comply with tolerances were scrapped and could not be put to any use, with the inventive use proposed at least one spacer element 35 advantageously allows the construction of reliable camera modules in which basically any mechanical focus setting can still be dispensed with. In particular the optical module can be assembled without any moving parts such as threads or fixing screws. The otherwise small tolerances of the layout, including in the x- and y-axis, mean that the chip surface 34 does not have to be unnecessarily large, which makes the camera chip smaller. The layout of such a module can be a comparatively compact design which has the

1 advantage that the camera module can also be used in
2 applications where space is restricted. Furthermore the layout
3 described offers the opportunity of designing a hermetically
4 sealed module which is protected against environmental
5 influences such as moisture or dust.

6 The features of the invention disclosed in this description, in
7 the drawings and in the claims can be of importance both
8 individually and in any combination for implementing the
9 invention. They are especially suitable for applications in the
10 interior and/or exterior area of a motor vehicle.

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